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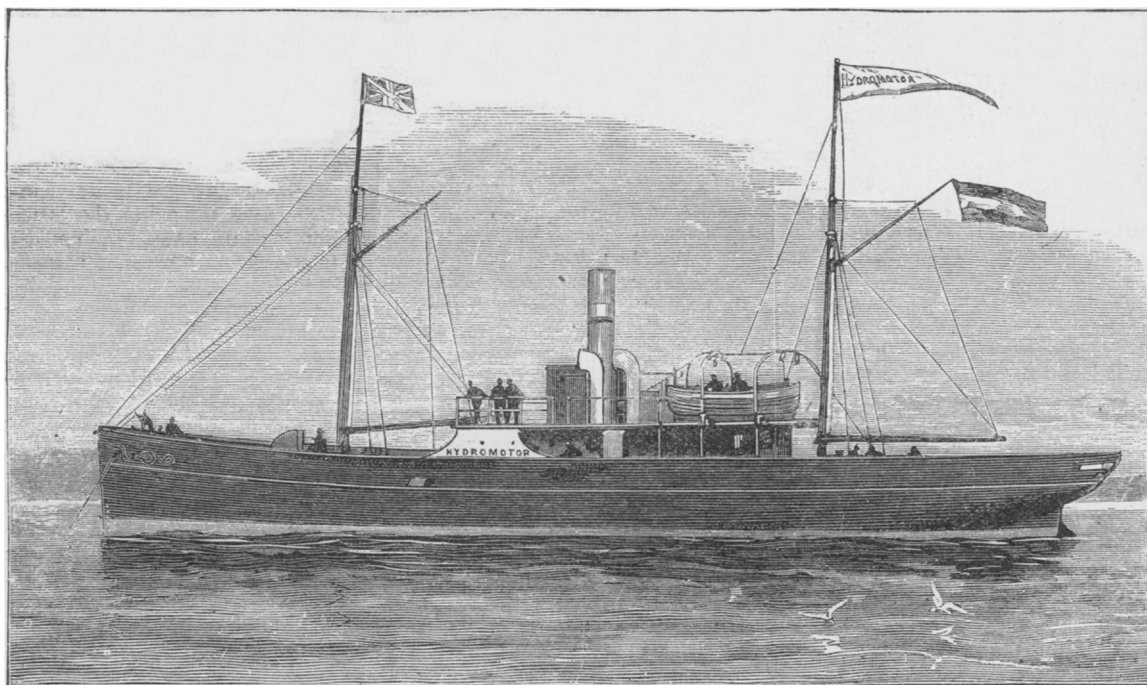
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THE VESSEL AS IT APPEARS AFLOAT

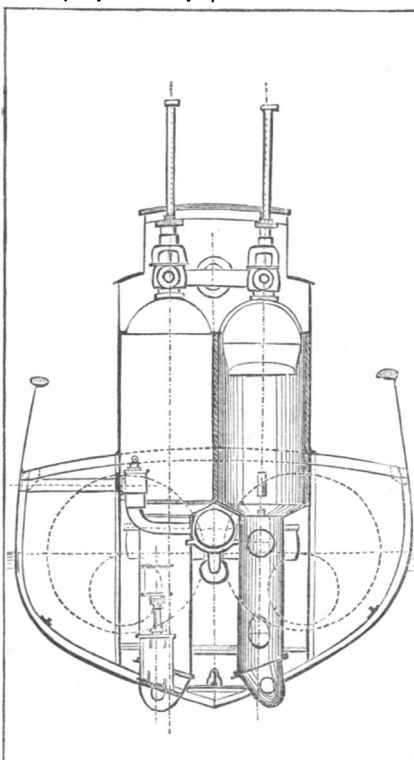
THE HYDROMOTOR SHIP.

We present a drawing of a vessel propelled by hydraulic reaction, and recently constructed at Kiel by Dr. Emil Fleischer, of Dresden.

Machines propelled on the reactive principle are by no means a novelty, but hitherto have been attended with indifferent success. Nearly 40 years ago a model boat, which used to travel up and down a tank propelled by such means, was exhibited in London. But Dr. Fleischer's hydromotor allows of as much as 90 per cent. of the indicated steam power being applied to the production of the outflowing water stream, while not more than 30 per cent. has been secured with the reaction machines hitherto constructed. In his vessel the usual ship's engines, worked by means of wheel or screw, are replaced by hydraulic reaction, by the drawing in and shooting out of a stream of water. The steam power acts immediately on the water, without any loss of such power in conveyance from steam engines and pumps. The manœuvring capabilities of the vessel are greatly increased, and the usual complicated machinery is replaced by a remarkably simple contrivance.

The professional men who took part in a short trip with the hydromotor, expressed the most unqualified appreciation of the invention, and of every detail of its execution. The easy manœuvring of the vessel, its small consumption of coal, and the practicability of adapting the system to all rates of speed were clearly shown, and the simplicity of its construction was regarded as particularly valuable for war ships. The hydromotor is undergoing further tests in English waters.

HYDRODYNAMIC ANALOGIES TO ELECTRICITY AND MAGNETISM.



From a scientific and purely theoretical point of view there is no object in the whole of the Electrical Exhibition at Paris of greater interest than the remarkable collection of apparatus exhibited by Dr. C. A. Bjerknes, of Christiania, and intended to show the fundamental phenomena of electricity and magnetism by the analogous ones of hydrodynamics. I will try to give a clear account of these experiments and the apparatus employed; but no description can convey any idea of the wonderful beauty of the actual experiments, whilst the mechanism itself is also of most exquisite construction. Every result which is thus shown by experiment had been previously predicted by Prof. Bjerknes as the result of his mathematical investigations.

It has long been known that if a tuning-fork be struck and held near to a light object like a balloon it attracts it. This is an old experiment, and the theory of it has been worked out more than once. Among others, Sir William Thomson gave the theory in the *Philosophical Magazine* in 1867. In general words the explanation is that the air in the neighborhood of the tuning-fork is rarefied by the agitation

which it experiences. Consequently the pressure of the air is greater as the distance from the tuning-fork increases. Thus the pressure on the far side of the balloon is greater than that on the near side, and the balloon is attracted.

Dr. Bjerknes has followed out the theory of this action until he has succeeded in illustrating most of the

fundamental phenomena of electricity and magnetism. He causes vibrations to take place in a trough of water about six inches deep. He uses a pair of cylinders fitted with pistons which are moved in and out by a gearing which regulates the length of stroke and also gives great rapidity. These cylinders simply act alternately as air-compressors and expanders, and they can be arranged so that both compress and both expand the air simultaneously, or in such a way that the one expands while the other compresses the air, and *vice versa*. These cylinders are connected by thin india-rubber tubing and fine metal pipes to the various instruments. A very simple experiment consists in communicating pulsations to a pair of tambours, and observing their mutual actions. They consist each of a ring of metal faced at both sides with india-rubber and connected by a tube with the air-cylinders. One of them is held in the hand; the other is mounted in the water in a manner which leaves it free to move. It is then found that if the pulsations are of the same kind, *i.e.* if both expand and both contract simultaneously, there is attraction. But if one expands while the other contracts, and *vice versa*, there is repulsion. In fact the phenomenon is the opposite of magnetical and electrical phenomena, for here like poles attract, and unlike poles repel.

Instead of having the pulsation of a drum we may use the oscillation of a sphere; and Dr. Bjerkes has mounted a beautiful piece of apparatus by which the compressions and expansions of air are used to cause a sphere to oscillate in the water. But in this case it must be noticed that opposite sides of this sphere are in opposite phases. In fact the sphere might be expected to act like a magnet; and so it does. If two oscillating spheres be brought near each other, then, if they are both moving to and from each other at the same time, there is attraction; but if one of them be turned round, so that both spheres move in the same direction in their oscillations, then there is repulsion. If one of these spheres be mounted so as to be free to move about a vertical axis, it is found that when a second oscillating sphere is brought near to it, the one which is free turns round its axis and sets itself so that both spheres in their oscillations are approaching each other or receding simultaneously. Two oscillating spheres, mounted at the extremities of an arm, with freedom to move, behave with respect to another oscillating sphere exactly like a magnet in the neighborhood of another magnetic pole. I believe that these directive effects are perfectly new, both theoretically and experimentally. The professor mounts his rod with a sphere at each end in two ways: (1) so that the oscillations are along the arm, and (2) so that they are perpendicular. In all cases they behave as if each sphere was a little magnet with its axis lying along the direction of oscillation.

Dr. Bjerkes looks upon the water in his trough as being the analogue of Faraday's medium; and he looks upon these attractions and repulsions as being due, not to the action of one body on the other, but to the mutual action of one body and the water in contact with it. Viewed in this light, his first experiment is equivalent to saying that if a vibrating or oscillating body have its motions in the same direction as the water, the body moves away from the centre of disturbance, but if in the opposite direction, towards it. This idea gives us the analogy of dia- and paramagnetism. If, in the neighborhood of a vibrating drum, we have a cork ball, retained under the water by a thread, the oscillations of the cork are greater than those of the water in contact with it, owing to its small mass, and are consequently *relatively* in the same direction. Accordingly we have repulsion, corresponding to diamagnetism. If, on the other hand, we hang in the water a ball which is heavier than water, its oscillations are not so great as that of the water in its vicinity, owing to its mass, and consequently the oscillations of the ball relatively to the water are in the opposite

direction to those of the water itself, and there is attraction, corresponding to paramagnetism. A rod of cork and another of metal are suspended horizontally by threads in the trough. A vibrating drum is brought near to them; the cork rod sets itself equatorially, and the metal rod axially.

If a pellet of iron be floated by a cork on water and two similar poles (*e.g.* both north) be brought to its vicinity, one above and the other below the pellet, the latter cannot remain exactly in the centre, but will be repelled to a certain distance, beyond which, however, there is the usual attraction. The reason is that when the pellet is nearly in the line joining the two poles the north pole of the pellet (according to our supposition) is further from this line than the south one. The angle of action is less; so that although the north pole is further away, the horizontal component of the north pole repulsion may be greater than that of the south pole attraction. Dr. Bjerkes reproduces this experiment by causing two drums to pulsate in concord, the one above the other. A pellet fixed to a wire, which is attached by threads to two pieces of cork, is brought between the drums, and it is found impossible to cause it to remain in the centre.

Dr. Bjerkes conceived further the beautiful idea of tracing out the conditions of the vibrations of the water when acted upon by pulsating drums. For this purpose he mounted a sphere or cylinder on a thin spring and fixed a fine paint-brush to the top of it. This is put into the water. The vibrations are in most cases so small that they could not be detected, but by regulating the pulsations so as to be isochronous with the vibrations of the spring, a powerful vibration can be set up. When this is done a glass plate mounted on four springs is lowered so as to touch the paint-brush, and the direction of a hydrodynamic line of force is depicted. Thus the whole field is explored and different diagrams are obtained according to the nature of the pulsations. Using two drums pulsating concordantly, we get a figure exactly like that produced by iron filings in a field of two similar magnetic poles. If the pulsations are discordant it is like the figure with two dissimilar poles. Three pulsating drums give a figure identical with that produced by three magnetic poles. The professor had previously calculated that the effects ought to be identical, and I think the same might have been gathered from the formulæ in Sir William Thomson's "Mathematical Theory of Magnetism," but this only enhances the beauty of the experimental confirmation.

Physicists have been in the habit of looking upon magnetism as some kind of molecular rotation. According to the present view it is a rectilinear motion. Physicists have been accustomed to look upon the conception of an isolated magnetic pole as an impossibility, but here, while the oscillating sphere represents a magnetic molecule with north and south poles, the pulsating drum represents an isolated pole. These are new conceptions to the physicists, let us see whither they lead us. The professor shows that if a rectilinear oscillation constitutes magnetism, a circular oscillation must signify an electric current, the axis of oscillation being the direction of the current. According to this view what would be the action of a ring through which a current is passing? If the ring were horizontal the inner parts of the ring would all rise together and all fall together, they would vibrate and produce the same effect as the rectilinear vibrations of a magnet. This is the analogue of the Amperian currents.

To illustrate the condition of the magnetic field in the neighborhood of electric currents, Dr. Bjerkes mounted two wooden cylinders on vertical axes, connecting them by link-work, which enabled him to vibrate them in the same or opposite ways. To produce enough friction he was forced to employ syrup in place of water. The figures which are produced on the glass plate are in every case the same as those which are produced by iron filings in the neighborhood of electric currents, including the

case of currents going in parallel and in opposite directions.

The theory is carried out a step further to explain the attraction and subsequent repulsion after contact of an electrified and a neutral substance and the passage of a spark. But it is extremely speculative, and is not as yet experimentally illustrated, and I think that at present it is better to pass it by,

I believe that the professor will exhibit his experiments and give some account of his mathematical investigations, which have occupied his time for five years, to the Académie des Sciences this afternoon. His results have not been published before. GEORGE FORBES.

THE ELECTRIC DISCHARGE THROUGH COLZA OIL.*

By A. MACFARLANE, D. SC., F. R. S. E.

The electrical properties of colza oil which I have examined are its dielectric strength and some phenomena which accompany the passage of the spark. By the dielectric strength of a substance I mean the ratio of the difference of potential required to pass a spark through air under the same conditions. The electrodes used were two parallel brass plates each four inches in diameter. When comparing the gases the standard distance of the plate chosen was 5 mm. In the case of liquids it is convenient to observe for a shorter distance, and reduce the result by the law which previous experiments of mine have established, namely, that in the case of the discharge between parallel plates through a liquid dielectric, the difference of potential required is proportional to the distance between the plates. (*Trans. R. S. E.*, vol. xxix. p. 563). One set of observations gave the ratio for colza oil to be 2.7, another gave 2.5. Hence 2.6 may be taken. I have now obtained the following table of dielectric strengths for liquids (1 being unity).

Substance.	Dielectric Strength.
Paraffine oil	3.7
Oil of turpentine.....	4.0
Paraffine liquefied.....	2.4
Olive oil.....	3.5
Colza oil.....	2.6

The specific gravity of the colza oil is .91. The passage of the spark was accompanied by the formation of gas bubbles, but there was no deposition of solid particles. As the 4-inch plates were placed horizontally in the oil a bubble produced by the discharge was prevented from escaping by the upper plate. When the upper plate is again electrified such a bubble behaves in the following manner. If it is large enough it will extend itself somewhat like an hour-glass between the plates, but if it is smaller it takes the form of an acorn with a flat base, the base resting on one or other of the plates. When the upper plate is charged positively the bubble is repelled so as to place its base on the lower plate; when the electricity is changed to negative the bubble remains with its base on the upper plate. A reversal of the order of charging did not change the effect. After a few electrifications a sufficient number of solid particles collect to form a chain, and thus interfere with the phenomenon, the bubbles then being lengthened out in a remarkable manner, but never repelled to the lower plate. When the upper plate was charged negatively, gas bubbles appeared to me to rise from the lower plate, as if they had been formed there. To test this point further I took some sparks between two smaller disks placed vertically in the oil. The gas-bubbles were observed to rise up at the negative surface as if they had been formed at the positive surface, and had been repelled or carried straight across, and then rose up at the negative surface. When the spark was taken between two points bent at right

angles to two rods dipping into the oil, the bubbles were observed to shoot out in the direction from the positively charged point, and to circulate round the earth-rod some time before rising to the surface. These phenomena indicate that the bubble is positively electrified.

ASTRONOMY.

ON THE POSSIBILITY OF THE EXISTENCE OF INTRA-MERCURIAL PLANETS.*

By BALFOUR STEWART, LL.D., F.R.S.

It is a somewhat frequent speculation amongst those who are engaged in sun-spot research to regard the state of the solar surface as influenced in some way by the positions of the planets.

In order to verify this hypothesis observers have tried whether there appear to be solar periods exactly coinciding with certain well-known planetary periods. This method has been adopted by the Kew observers (Messrs. De La Rue, Stewart, and Loewy), who had an unusually large mass of material at their disposal, and they have obtained from it the following results:—

1. An apparent maximum and minimum of spotted area approximately corresponding in time to the perihelion and aphelion of Mercury.
2. An apparent maximum and minimum of spotted area approximately corresponding in time to the conjunction and opposition of Mercury and Jupiter.
3. An apparent maximum and minimum of spotted area approximately corresponding in time to the conjunction and opposition of Venus and Jupiter.
4. An apparent maximum and minimum of spotted area approximately corresponding in time to the conjunction and opposition of Venus and Mercury.

The Kew observers make the following remarks upon these results:—

"There appears to be a certain amount of likeness between the march of the numbers in the four periods which we have investigated, but we desire to record this rather as a result brought out by a certain specified method of treating the material at our disposal than as a fact from which we are at present prepared to draw conclusions. As the investigation of these and similar phenomena proceeds, it may be hoped that much light will be thrown upon the causes of sun-spot periodicity.

The Kew observers have likewise produced evidence of a different kind in favor of the planetary hypothesis, for they have detected a periodicity in the behavior of sun-spots with regard to increase and diminution apparently depending upon the positions of the two nearer planets, Mercury and Venus. The law seems to be that as a portion of the sun's surface is carried by rotation nearer to one of these two influential planets, there is a tendency for spots to become less and disappear, while on the other hand, when it is carried away from the neighborhood of one of these planets, there is a tendency for spots to break out and increase.

But whatever truth may be in these conclusions, it appears to be quite certain that periodical relations between the various *known* planets will not account for *all* the sun-spot inequalities with which we are acquainted. They may account for some, but certainly not for all. For there are solar inequalities of short duration which presuming them to be real, can only be accounted for on the planetary hypothesis, by supposing the existence of several unknown intra-Mercurial planets.

Indeed these short-period inequalities in sun-spots and the allied phenomena of terrestrial magnetism and meteorology have so augmented in number of late years as to make some observers inclined to question their reality; while others again resort to the above-mentioned hypothesis, and attribute them to intra-Mercurial planetary agency.

The method to be pursued in detecting the existence

* British Association, 1881.

* British Association, 1881.